

- III. "Effects of Stress and Magnetisation on the Thermoelectric Quality of Iron." By Professor J. A. EWING, B.Sc., University College, Dundee. Communicated by Sir WILLIAM THOMSON, F.R.S. Received February 24, 1886.

(Abstract.)

This paper comprises a revised version of one submitted to the Royal Society in 1881, under the title "Effects of Stress on the Thermoelectric Quality of Metals, Part I,"* along with much new matter. It deals principally with the cyclic changes of thermoelectric quality which an iron wire undergoes when exposed to cyclic variations of stress (described in the abstract of the former paper), and with the relations of these changes of thermoelectric quality to the changes of magnetism which also occur as an effect of stress. Stress was applied by exposing the wire to longitudinal pull by means of loads. The changes both of thermoelectric quality and of magnetism exhibit that tendency to lag behind the changes of stress to which in a previous paper† the author gave the name *hysteresis*, and the effects are sufficiently similar in regard to the two qualities to suggest that the changes of thermoelectric quality occur as secondary effects of changes of magnetism. To examine whether this is the case, simultaneous measurements of the magnetic and thermoelectric effects of stress in an iron wire were made, and also independent observations of the thermoelectric effects of magnetisation, without change of stress. A comparison of these made it clear that stress causes change in thermoelectric quality of iron directly, and not as a secondary effect of magnetisation. If the wire be completely demagnetised to begin with, and kept clear of all magnetisation during the application and removal of stress, the presence of hysteresis is not less marked than before. Experiments are given to show how the thermoelectric effects of stress are modified by the existence of more or less magnetisation in the wire; and conversely, how the thermoelectric effects of magnetism are modified by the existence of more or less constant stress. The influence of vibration in destroying the effects of hysteresis is investigated, and also the result of exposing the wire to the process of demagnetising by repeated rapid reversals of a continuously diminishing magnetising force, and it is shown that this process acts in the same way as vibration in destroying the effects of hysteresis. Residual effects of hysteresis are studied, as, for example, the difference which presents itself when a wire is magnetised after having

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† "Proc. Roy. Soc.," No. 216, 1881, p. 22.

been loaded strongly and then unloaded down to a certain constant state of stress, and, on the other hand, when the same state of stress has been produced by simply increasing the load ; and it is shown that these residual effects are wiped out by vibration or by demagnetising by reversals. With regard to the effect of stress on thermoelectric quality, it is shown that if a somewhat soft wire be more and more strongly magnetised, these effects become more and more similar to those which are found when the wire is hard drawn, but not magnetised. A few experiments were made with wires of silver, copper, lead, magnesium, and German silver, but in none of these was hysteresis of thermoelectric quality with regard to load discovered.

Special attention is directed to a peculiar feature in the curves by means of which the experimental results are exhibited. In curves showing the relation of thermoelectric electromotive force to load, it is shown that any reversal from loading to unloading, or *vice versâ*, causes an inflection in the curve, the first effect of the new process being to continue the kind of change that was going on before. That this is not due to any mechanical disturbance which the loading or unloading produces, is shown by the fact that it occurs in an equally marked way after the molecules have been brought to a condition of stable equilibrium by vibrating the wire before beginning to load or unload. It is suggested that the effects of hysteresis, described in the paper, have a possible relation to the properties which Professor Osborne Reynolds has recently shown to be possessed by granular media.

The experiments described in the paper are closely connected with those which were communicated in January, 1885, under the title "Experimental Researches in Magnetism," and are now being published by the Society. They were conducted in the Physical Laboratory of the University of Tokio, in 1881-3, partly with the help of one of the author's Japanese students, Mr. P. S. Sakai. The results are given graphically, and are for the most part reduced to absolute measure.